Cognitive economy and satisficing in information seeking: A longitudinal study of undergraduate information behaviour.

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Abstract

This paper reports on a longitudinal study of information seeking by undergraduate Information Management students. It describes how they found and used information, and explores their motivation and decision making. We employed a use–in-context approach where students were observed conducting, and interviewed about, information seeking tasks carried out during their academic work.

We found that participants were reluctant to engage with a complex range of information sources, preferring to use the internet. The main driver for progress in information seeking was the immediate demands of their work (e.g. assignments). Students used their growing expertise to justify a conservative information strategy, retaining established strategies as far as possible and completing tasks with minimum information seeking effort. The time cost of using library material limited the uptake of such resources. New methods for discovering and selecting information were only adopted when immediately relevant to the task at hand, and tasks are generally chosen or interpreted in ways that minimised the need to develop new strategies. Students were driven by the demands of the task to use different types of information resources, but remained reluctant to move beyond keyword searches, even when they proved ineffective. They also lacked confidence in evaluating the relative usefulness of resources.

Whereas existing literature on satisficing has focused on stopping conditions, this work has highlighted a richer

repertoire of satisficing behaviours.

Introduction

This paper reports the findings from a longitudinal study of the development of expertise in information behaviour in a group of Information Management undergraduate students over the first two years of their degree. The aim of the study was to find out how expertise in using a range of information sources, both physical and digital, increases over time. It was thus important to study a group of students over a relatively long period, in the expectation that their information behaviour might become more complex and expert, as they progressed through their course. We deliberately chose a group of students in information management as they were being taught how to find, evaluate and make most effective use of information in a much more overt way than in other areas of undergraduate studies. We expected that what they had learnt would influence their subsequent behaviour.

In this paper, we discuss numerous aspects of students' information work, including information seeking, evaluation of information, and the use of a variety of materials, both digital and in print. Most significantly we discuss the nature of the expertise students achieved as independent information users. In particular, we discuss what kinds of resources they prefer to use, and why, and what confidence they have in evaluating the usefulness of information relative to specific tasks.

Out initial assumption was that the period of undergraduate study should provide vital clues into the ways in which expertise is acquired in information work. It marks the transition between school, where students are typical given significant guidance in seeking and using information, and either graduate study or the work environment, where students or employees are expected to be more autonomous in their information behaviour. During the first degree, we therefore expected to see a change from directed searching to much greater expertise and independence. It was therefore vital that the study should be longitudinal, and over as long a period of time as possible, to allow us to observe change over time. It was also important that the study should not only concern seeking, but a broader range of information use, so that we could determine how expertise changed in different aspects of information behaviour.

Previous work in the area

There have been numerous studies of information behaviour, in terms of use of different types of resources, information seeking and information needs in young people, students and adults. However, the focus of this paper is on the acquisition of expertise in information behaviour, and therefore we have concentrated on reviewing literature which discusses expertise, or presents longitudinal studies of students. The subject of young people and information

seeking has recently become newsworthy, thanks to the study by Rowlands et al (2007), who provide an excellent discussion of the literature in this area. Although in the course of our discussion we compare our findings to studies of young people's information seeking, discussions of this area and of theories of information seeking itself are beyond the scope of this paper.

Studies of expertise

Definitions of expertise vary widely, and have altered over time, and for this reason we have not adopted a single definition. Nevertheless we initially adopted the assumption present in most of the literature, that expertise is related to experience. Thus the more experience participants in studies have of using certain types of information sources, or the more knowledge they have about how to conduct certain types of search, the more expert we would expect them to become. Most previous studies of expertise take the form of a comparison between expert and novice users searching different information systems or the web (Chu & Law, 2007b). Not surprisingly, these have found that experts have much more complex information seeking strategies. They will persist for longer with searches, use more varied strategies and more diverse sources, use both browsing and searching, and reformulate queries if an initial search does not produce useful results (Holscher & Strube, 2000; Hsieh-Yee, 1993; Aula et al. 2005; Cothey, 2002). Good knowledge of the subject domain is also vital (Vakkari, 2002; Kuhlthau, 2004). When comparing a group who had expertise in information seeking with another group they call "double experts", i.e. experts in information seeking and the subject domain of the search, Holscher and Strube (2000) found that domain knowledge helps participants to select query terms that are more likely to produce a result set of useful size and quality. Expert searchers also use more synonyms (Hsieh-Yee, 1993; Vakkari, 2001); however, there is no consensus about their use of complex search expressions involving truncations, Boolean operators and phrase searching. Holscher and Strube (2000) and Chu and Law (2007a) found greater use of Booleans, but Aula (2005) and Hsieh-Yee, (1993) found fewer Boolean queries being used by experts. This has been seen as evidence either that expert searchers can construct more complex queries, or that they are able to select exactly the right term to gain useful results. The complexity of search terms is also dependent on the information task (Cothey, 2002). It is important to stress that studies have been carried out over a period of time when interfaces and systems have changed markedly. Thus the results of studies of searching may differ because of the use of different search engines on the web and differing digital library functionality. This is to be expected, since Sutcliffe and Ennis (1998) stress that search expertise is likely to be affected by not only domain knowledge, search skills and available resources, but also the characteristics of the system. Within these factors, therefore, there is significant scope for variation when advanced strategies such as

Boolean operators are taken into account.

Experts and novices

Historical changes in information systems being searched may also account for differences in the definition of expert and novice in the literature. Studies from the 1980s defined novices as those who had not undertaken independent online searching, or had undertaken a beginners' course in information seeking, (Howard, 1982; Harter, 1984) and defined expertise in terms of the number of searches carried out over a certain period, for example a month, (Howard, 1982) or for a certain time prior to the study (Harter, 1984). Later studies have followed a student group from relative inexperience to the attainment of far greater expertise (Whitmire, 2002; Vakkari, 2001; Wilson et al. 2002; Kuhlthau, 2004; Spink et al., 2002a and b), and thus the experts and novices are, in effect, the same group of participants at different stages of development. Librarians have also been used as an expert group from whom lessons may be learnt for the design of digital library systems (Fields et al., 2004).

As the ability to search digital libraries without intermediation has become widespread, it is more difficult to find a truly novice sample. Novices tend now to be defined as those who are unfamiliar with a certain digital library (Blandford et al., 2001) or who, as in our study, have done little independent information seeking in an academic context. Vakkari (2001), for example, even regards MA students who have gained a first degree in Information Studies as relative novices in information seeking. The study reported here provides further evidence that a first degree in an information discipline is not a passport to search expertise. Our working definition of an expert is therefore someone who is an experienced, confident user of information, who is able to chose appropriate strategies to find what they need, and to evaluate the usefulness of the resources that they find to address a given information problem or task. A novice is someone who has not reached this level of competence.

Studying the development of expertise

To understand how expertise develops, it is necessary to take a long-term view. As Chu and Law (2007a and 2007b) observe, there is a relative lack of longitudinal studies of the development of expertise, especially amongst students. Although numerous other studies of information seeking have used undergraduate students as their participants, including Spink et al (2002), Whitmire (2002), Fescemyer (2000), Kim (2003), Wilson et al. (2002a, 2002b.), Ford et al, (2002), Cothey (2002), Cole et al. (2005), Urquhart et al (2003, 2005), Rowley & Urquhart (2007) and Urquhart & Rowley (2007), they have tended to concentrate on how specific search tasks are carried out rather than tracking change over time. Although Whitmire (2002) studied the way that information seeking is related to the development

of epistemology in undergraduates, she focused on the results of the process, rather than its early development, and thus took final year undergraduates as her sample. Cothey's (2002) study used web server transaction logs to study changes in undergraduate information seeking, analysing them at different points in the academic year. As she admits, this method captures overall patterns, but does not explain details of individual information behaviour. Urquhart and her research team (Urquhart et al, 2003, 2005; Rowley & Urquhart, 2007; Urquhart & Rowley, 2007) carried out a large scale longitudinal study of the use of electronic information resources in UK higher education over a five year period. They used various qualitative and quantitative sampling methods, and included undergraduates, postgraduates, librarians and academics. As a result of their study they constructed a complex model of electronic resource use in higher education, and of the macro and micro factors that may encourage it. However, this differs from out study since it necessarily deals with the analysis of very large patterns of behaviour over several different universities and student cohorts rather than detailed observations of the behaviour of a group of students as they progress through an undergraduate course.

This kind of longitudinal study of detailed development was undertaken by Chu and Law, who studied PhD students over a year, and by Vakkari (2001), who studied taught postgraduate students over a four month period. Kuhlthau (2001, 2004) also undertook a longitudinal study of high school students while creating her model of stages of information search. Wilson et al (2002a, 2002b) and Spink et al (2002b) have also studied the way that undergraduate searches may change over time. However, the focus of their joint project was to identify how the different stages of a project, from initial surveys of a large field to the final reference check after an article is written, may affect how information seeking is carried out. In the case of Spink's group, this was also supported by the analysis of search engine logs to map large behaviour patterns. Both groups studied change over time, and the way in which individual differences, such as cognitive styles and affective factors, may affect searches. However, like Vakkari and Kuhlthau, the focus of these studies is on how the search process changes, rather than how individuals develop as information seekers and analysts, which is the focus of our study.

Studying use in context

Many studies of undergraduate information seeking have been carried out in a laboratory context, with students undertaking set tasks in an unfamiliar setting. However, real information work does not take place in the laboratory. A few studies have employed a use-in-context approach, during which students were interviewed about and observed seeking information to support a real assignment or piece of research (Whitmire, 2002; Vakkari, 2001; Chu & Law, 2005, 2007a, 2007b; Attfield et al., 2003). As Martzoukou (2005) observes, this is relatively rare, since most user

centred studies of information seeking rely on tasks which are artificial to at least some extent. A use-in-context approach means that tasks are relatively complex, and often involve searching multiple information sources, typically over many information seeking episodes.

Research Design

The aim of this study was not to answer a pre-existing research question identified from gaps in the literature, but to develop a rich understanding of how expertise develops over time in an educational context – in this case, of an Information Management undergraduate programme. Our assumption, which was not borne out by the study, was that this particular cohort of students would develop skills reasonably rapidly and clearly, and thus provide a model of how skill acquisition might be supported for students with less specialist training. In order to build a rich, contextualised understanding, we adopted a longitudinal, use-in-context approach, studying information tasks that were given to students as part of their course of study rather than ones that were designed to find out particular things about their information behaviours. This meant that the participants themselves defined the direction of the study, meaning that we might not find exactly what we were hoping for as a result.

Overview

The study collected qualitative data about student information behaviour, since we wished to study not only patterns of behaviour, but also the motivations for them and students' opinions about the resources that they chose to use. This data was collected via an initial questionnaire and subsequently four individual semi-structured interviews and observation sessions, which took place at approximately six-monthly intervals. Interviews were also conducted with course tutors, to allow us to understand the rationale for the courses, and what the objectives for student learning were intended to be. The information below about the views or expectations of academics is derived from these consultations. The same researcher was responsible for liaising with the participants and facilitating each session.

The educational context

Participants were recruited from a new cohort of Information Management undergraduates at the very start of their degree in October 2005, and we followed their progress to the end of their second year. Twenty seven students were registered for this degree but four dropped out during the first year. Teaching and learning was carried out in lectures, practical sessions in computer labs, and small group tutorials, and assessments ranged from group projects assessed by coursework, to individual technical assignments such as web design and programming, to examinations,

which were usually unseen. Students had access to library facilities on campus, and to open access computer clusters, although many of them chose to access information resources from home or a hall of residence, via the internet. As noted above, the choice of degree course was significant, since one of the aims of the course is to advance the information skills of the students, and they study a module on information sources and how to use them in the first year. In theory, therefore, students taking this course had an excellent chance of improving their levels of information seeking expertise. We considered it important to follow a group from the very beginning of their course, so that we could track their development in relation to their information tasks, and could ascertain their level of prior knowledge.

All the data collection episodes were based on modules that were compulsory for the Information Management students. The list below provides details of the timing of the studies and the context of the work that the students were engaged in.

Year 1 Term 1

During the first interview and observation session, the interview investigated participants' prior knowledge and experience of information seeking, for example for school assignments, and what resources and information technology students used, as well as the course assignments. The assignments, for the Foundations of Management module, were a book review, seeking information on a company and preparing a presentation (a mixture of individual and group work).

Year 1 Term 2

We studied information seeking for the Entrepreneurship course; the assignment was to develop a website on a topic from a variety of sources.

Year 2 Term 1

We studied students' information seeking for the Management Information and Control course, for which they had to develop a business plan, and also interviewed them about how they had revised for the previous term's exam.

Year 2 Term 2

The final data collection episode focused on work carried out in preparation for a seen examination in Cognitive Science.

Data Collection

During induction week (prior to the data collection sessions listed above), students were given a brief questionnaire that captured basic demographic data. Those who completed and returned it were invited to participate in the research. Thirteen students did so (though, as discussed below, only seven participated in all study sessions). Participation was voluntary and they were given a small financial reward (£6 per session). Confidentiality was assured, and each participant was assigned a code for each data gathering session when the data was analysed. Thus P1Y1T1 indicates participant one, year one term one. The appropriate ethical clearance was obtained at the start of the research.

The observation/interview sessions were conducted in a small computer room within their main department, a familiar environment for all students. The same researcher was the observer/interviewer at all sessions. A networked computer in the room was set up with Camtasia screen recording software to video online activity, and a digital voice recorder was used to capture the participants' responses to questions. In each session, which lasted about an hour, the participant was interviewed about their general information behaviour and then observed conducting an information task, such as a web search, during which they were asked to think aloud, and their interaction was captured using the Camtasia software. The information work which the students described in interviews might have been carried out in computer rooms at the university or from home or by visiting the university library in person.

Participants

Table 1 (below) gives details of the participants in our study. It shows that some students also dropped out during the study. This is inevitable in a study of this length, given the many demands on students' time. In particular, the second year was significantly more demanding that the first year and, as discussed below, the Cognitive Science course was perceived as being particularly challenging.

Table 1. Details of study participants

All the participants were of typical undergraduate age except P2, who was a mature student. His experience was very different from that of the other students. He had not grown up with the internet, and described the use of traditional resources such as encyclopaedias for his school work. However, he was a confident internet user, having sought information to support his work. His greater experience gave him a more sophisticated level of information

expertise than the standard age undergraduates. He also proved much more capable of reflecting on his information seeking practices and those of the standard age students. In many senses he was a kind of vicarious action researcher, who observed and commented on the behaviour of his fellow students, rather in the manner of a second researcher. We have therefore included some of his comments, to contextualise our own observations.

Data Analysis

Interviews and think alouds were captured using a digital voice recorder and transcribed verbatim. They were systematically analysed by two independent researchers, each iteratively working through transcripts, coding the data and identifying and cross-relating key themes, but there was no *a priori* code book. The approach used was based on thematic analysis techniques described by Wetherell, Taylor and Yates (2001) and Emergent Themes Analysis (Wong and Blandford, 2002). The authors read the transcripts and discussed the findings as a means of ensuring some inter-observer reliability. For clarity of reporting, stumbling and hesitations have been removed from the illustrative quotations where they do not carry any interpretive meaning.

Results

Prior knowledge

It is important initially to discuss the level of prior knowledge and expertise possessed by participants. As discussed above, it is now very difficult to discover complete novices, and this proved to be the case with our participants, whose skill levels already varied significantly at the beginning of their course. Some students did not exhibit significant independent information seeking behaviour. Typically, students reported using a limited range of information sources at school, mainly comprising textbooks, and print resources set for them by their teachers, such as newspapers, magazines and television, and occasionally CD-ROMs such as Encarta. However, they reported that towards the end of their schooling, they were directed by teachers to carry out basic internet searches to support their coursework, or used online learning resources, for example from the BBC. Internet usage was primarily for socialising and communication, and information seeking on the web was usually for cinema information and transport timetables, rather than for their coursework. A few students reported that their schools strictly limited their use of web-based email and search engines.

However, there was variation even within this general level of expertise and some participants were capable of quite complex information behaviour, even at the beginning of the course. For example, P4 discussed her use of textbooks:

> I would read the recommended book first and if I needed to elaborate or understand something further I'd go to the Internet or ask the teacher or ask some friends and stuff but I didn't necessarily go to the Internet first. I'd read up from some books before because I don't really 100% trust the Internet. [....] I go on Amazon and find a cheap book, I did that for A levels as well, I sometimes find that the books they give are too detailed, so I go and find like an A level book and read the background, some basic stuff on it, and then go and read others. (P4Y1T1)

Thus we can see that she is using a variety of different techniques to finding information. Her reliance on other people for advice confirms Urquhart et al. (2003)'s finding that students rely on the opinion of peers when searching for information. Indeed, we found that throughout the study students regularly reported using particular strategies or resources because they knew their peers were doing so. However P4 also compared the opinions of peers to the advice of her teachers. She also used Amazon for simple contextual information, about the level of the books she might need and read others' comments about books, and their opinion about the top ten books in a particular area. Although this may indicate that she relied on the judgements of others above her own, it still demonstrates a relatively sophisticated ability to compare different types of meta information in order to find the books that would be appropriate for her.

P13 already showed a level of relative sophistication when deciding how to design an information search for his first term assignment on performance measurement of British Airways. He broke the task down into elements for which he could perform keyword searches:

> How I interpret it is things like how many passengers were taken on board, like flight distances and that sort of thing, fuel consumption. (P13Y1T1)

He also explained that he drew upon knowledge that he had acquired as part of his A Level in business studies. When searching the internet, all participants had carried out simple keyword searches, almost all of them using Google to do so. They were confident that they could find useful information by doing so. However, as Gross and Latham (2007) point out, this kind of confidence is common in young people, who often over rate their ability to search the internet, when this is compared with performance in information literacy tests.

Nevertheless, some students showed a higher level of ability, notably P4 and P13, who were able to perform phrase searches. P13 had learnt more complex techniques than his peers from his father, an IT professional, and had therefore begun to use techniques more common in information experts. P13 also showed a willingness to compare information found on different websites.

> I wouldn't just look at one site and stick there, I would compare all the different results to see what was most relevant really, because obviously some websites are better than others and who they are written by as well. (P13Y1T1)

This willingness to compare the usefulness of the results found is notable since it is relatively uncommon for young people to reflect on the authority and quality of material found on the internet (Hirsch, 1999; Shenton and Dixon, 2003).

To summarise the state of prior knowledge that we found: the students were not complete novices as they began their course. All could perform basic keyword searches on the web, and had used libraries and printed information sources suggested by teachers or peers. The level of expertise was not uniform, however, and some of them were able to use relatively complex techniques to find the information that they needed.

Use of the information resources

Initially, students used techniques learnt in school or municipal libraries to help them find information, such as physically browsing relevant sections, as opposed to searching online catalogues. Although all but one of the students had attended an introduction to the library during induction week, we found little evidence that they had assimilated this information. Indeed, throughout the period of the study, students were reluctant to use the library, only doing so when they could not avoid it, or when coursework mandated it.

> I just use the library because for the coursework they require you to have as many sources as possible, so that's why I use it otherwise I only use the internet, it's easier. (P5Y1T1)

Using library books was perceived as both more difficult and less interesting than internet based resources. P8 revealed his limited knowledge of the library resources and dislike of books, compared to an online newspaper:

> Interviewer: Do you know what other resources they have?
>
> P8: Journals er Financial Times that's what I have to read for tutorials. So apart from boring books I read the Financial Times.
>
> Interviewer: So you actually read the Financial Times – is that in paper?
>
> P8: No, no online. (P8Y1T1)

By the second year, use of library books had waned significantly as students became better at finding reliable information online. They reported that the process of checking out and returning library books was onerous, found books heavy and were concerned that printed information might be out of date. It is reasonable for students with growing expertise to conclude that printed resources have disadvantages in terms of accessibility, portability, and

currency (Burton & Chadwick, 2000) and such advantages have long been known to be significant drivers of the popularity of electronic journals (Tomney & Burton, 1998). However, as P8's remarks above about boring books exemplify, they considered using books less interesting, fast and enjoyable than using web based information. Participants were also initially unwilling to use journals unless forced to do so. When asked whether he chose which journals to read to support his coursework in his first term, P13 replied "not really, just whatever journals I'm told to look up".

The most significant reason for use of library facilities was the information task, usually coursework assignments. Although in the first year comprehensive lecture notes were produced, which P9 thought "would have been enough to pass on", in the second year, handouts were not given for many of the courses. This was a deliberate policy by academic staff, who told us that they hoped it would force the students to develop their own information seeking skills. As the course progressed, students were therefore required to demonstrate a higher level of expertise in information seeking in order to complete assignments, as P2, the mature student, reflected:

> We had to do a lot of research and for many students it would have been the first time they've looked outside of their reference books… unless you were proactive and followed them [the lecturers] and asked 'well what exactly is it I'm meant to deliver' then you would be really stuck, so he [the lecturer] didn't give a lot, this was a big difference to last year, I think it's possibly about getting students to be more proactive, take more initiative as a group and as individuals it was a case of, well you've been asked to do something, wake up and say 'what have we been asked to do', so unless those students pipe up and ask, I think that's why there has been a big pressure on students this term, because a lot of them are realising they haven't been told what to deliver, and they are used to being spoon-fed what the actual guidelines of the coursework are. (P2Y2T1)

Students were expected to conduct more complex and exhaustive searches and use a wider repertoire of resources to satisfy the requirements of the assignments set. In a term 2 assignment, for example, students were penalised if they had only used a company's own website to find out information on an aspect of performance. They also realised that they would have to use resources beyond those found on the web:

> It doesn't look good to constantly write URLs in your referencing. I would try to minimise the list, I wouldn't want just crap off the internet basically, because it shows that you haven't got out much, like you looked for something physically doesn't it. You just need one or two books to break it up a bit, to show that, yeah, I've done my own reading and stuff. (P10Y2T1)

Students also showed a growing awareness on the quality of different types of information source and their relative usefulness for coursework assignments. Although we have seen above that P13 was aware of this when he began the course, several other students came to this realisation as a result of greater experience, and of formal teaching. When asked whether he had thought about such issues before P9 replied:

> To be fair I didn't, I mean I did use dot edu and dot org before anyway, but I did use dot coms as well, I used it on this coursework anyway because I'd found it after they had said it but you did sort of think, yeah, might not use dot com as much, I do use Google scholar a lot as well, that's scholarly papers, so that's pretty good. (P9Y1T2)

This suggests therefore that participants had responded to the demands of the coursework by showing a more complex appreciation of the type and provenance of information available to them. Thus they have moved away from the typical behaviour of younger information seekers and adopted a more complex view of information sources, which can be seen as a development of expertise.

Search strategies

Even in the context of task orientation, we found a difference in the extent to which students were willing to try different types of source as compared to their willingness to experiment with search strategies.

In almost all cases, students showed a marked tendency to interpret the demands of the coursework extremely literally when constructing search strategies. It was very common for them simply to use terms from the titles of their assignment or research project to conduct keyword searches. For example for an assignment on writing a business plan P13 entered the terms "writing a business plan" into Google because "obviously with business plan they just throw up a lot of things" (P13Y1T2). This strategy was used even when searching different types of information system. P8 picked words from the assignment handout, even when looking for books in the library catalogue: "I typed in "management of an organisation" to try to get books and then find something on management and safety." Other students used the same strategy when looking for journal titles, and tried to use the digital library interface as they would Google. This led to frustration:

> [I'm looking for] Information management anyway, but if management would come under there, otherwise, I would probably just use it alphabetically, if you select the initial letter of the journal that you are looking for – now I don't know what journal I am particularly looking for. See this is just loads of… I cant really search for titles, because I don't know what they are, something with a different title might be what I'm looking for – it might not clearly say management or whatever I'm

looking for. (P9Y2T1)

The student became confused because results were not presented in a familiar way and he lacked the domain knowledge to understand the significance of the titles that he was presented with. Thus, the keyword search technique proved ineffective. Yet the same student described using the same technique to search for information about the video gaming industry, which failed, quite understandably, to produce any relevant journal titles. In the most extreme example, a student was undertaking a project on customised trainers, but could not understand why she was unable to find relevant materials in the local library. When asked if she was looking for books in particular she replied:

> No, but just any old, just articles or anything, but nothing came up, that's why I thought I should maybe change my business idea to something a bit more common, I was looking in papers as well, and I was thinking about a dance school but I think there is too much competition in that so there's no point setting that up in the city.
>
> Interviewer: Right OK, so you just stuck with using the search term 'customised trainers'?
>
> Yeah, or 'personalised trainers', and then I went onto the Nike site and I was just like looking up stuff on there. (P10Y1T2)

As in all other cases where students undertook such keyword searches, she did not seem able to broaden out the search and undertake searches on general topic areas, or use subject searches on synonyms. Her response to not finding what she wanted was instead to think about changing her research topic. When this search failed, she decided to try a different information source but with the same keyword strategy. This was typical of the way that many students conducted searches. They often became frustrated or anxious when they failed to find what they needed, but would then simply move on to another website or search engine, rather than altering their approach to searches. Here P8 describes what she did after an unproductive search.

> Interviewer: Did you go to Yahoo again?
>
> P8: And Google, because I can't get information from Yahoo so I got so freaked out! I have to search somewhere else. (P8Y1T1)

Although this is a search session from term 1, we found the same time of behaviour throughout the study. This suggests that the students did not move away from the type of search strategy typical of children and young people (Hirsch, 1999, Chen, 2003). They were very unwilling to move far from the demands of the assignments set for them, preferring to use terms from titles or handouts rather than engaging in broader interpretation of the subject

matter.

Nevertheless, one somewhat unusual example of a forced improvement occurred in the work of P4 who, as we have seen above, already used more complex search strategies than her peers at the beginning of the course. She was searching for a journal on a reading list:

> I had no idea of how to find it, I went on Google, so I got frustrated and phoned the library and asked how do I find these journals and stuff, and they said go through Lexis Nexis, and talked me through it, if it wasn't for them then I wouldn't have known how to. (P4Y2T1)

Here, when the familiar seeking repertoire broke down, the student finally turns to acquiring new knowledge. In fact, this sort of information seeking had been taught, but it was finally acquired and deployed when ingrained approaches did not suffice. This marks the beginning of the more traditional process of development as an information seeker. However, it is atypical of our participants' behaviour.

Summary of early developments

In this section we have shown that the demands of the information task were central in determining how students used information resources and constructed search strategies. They tended to avoid books, journals and the physical library if possible, preferring to conduct a web search, viewing it as quicker and more convenient. However they would use a greater range of resources if it was necessary to pass an assignment. They also began to reflect on the quality and trustworthiness of the information that they found, and used different online and some printed sources for comparative purposes. In terms of their use of and reflection on information sources, they moved from typical teenage information behaviour towards a measure of expertise. However, we observed much less change in information seeking strategies. Most students remained unwilling to move away from strategies that they were used to, such as keyword searches, even if they proved ineffective. If a search failed they would move on to another search engine or type or resource, but tended not to try to use a new technique or strategy.

A form of expertise: strategic satisficing

By the final stages of our study, students had become aware of exactly how much information they needed to produce work of an acceptable standard. They could rapidly identify how well their existing search skills could be applied to answer an information problem, and would select problems that seemed most readily answered through familiar information seeking strategies, such as keyword searches. For these chosen problems, participants knew how to find sufficient information as quickly as possible using their extant skills. We term this "strategic satisficing".

At this stage of development, students are aware of what is needed to fulfil the demands of a task, but use their skill and ingenuity to construct simpler search goals that exploit ingrained skills. This can be seen most clearly in relation to their work for a seen examination in cognitive science in the second term of their second year.

In this case, the lecturer gave the students the exam paper several weeks in advance; students were required to prepare answers to two questions from a set of six alternatives. Each question was followed by one or two indicative references as a starting point for information seeking. This assumed a relatively high level of expertise, since students were expected to prepare answers using material from lectures as background reading, and then to conduct their own research by chaining from the references given. Information from lectures was intended to help students to decide which information found in their research might be useful for the examination.

However, we found that the students used the expertise that they had, by now, gained in information seeking to create time-saving strategies to complete the coursework with minimum effort, rather than harnessing their skills to complete an excellent assignment. This was partly caused by the difficulty of the course: many students admitted that their attendance was poor, whether because they were unenthusiastic about the subject matter or because they could not understand it. P2 proved insightful about the course and the struggles of his contemporaries:

> It was a completely different type of course than the one we had done in the other module and for many people it was outside their comfort zone in terms of understanding, mainly because it has a very expansive terminology, full of jargon, and to make sense of the underlying principles takes more than just to attend the lecture, that's pretty obvious… you couldn't get away with turning up to the lectures having listened to what was said… and the fact that the exam paper was by prior disclosure didn't help at all. (P2Y2T2)

Students were therefore forced to both acquire domain knowledge and develop their own information strategies, first amongst which was question selection. The following criteria were reported by participants in their selection of which questions to attempt:

- How long is the question?
- How many lecture notes did students have?
- Are the references given URLs or books?
- What is the topic of the question?
- How much information has to be memorised to answer the question – dates etc?

P4 chose questions that allowed her to avoid books and find initial information on the web:

> There were some questions that you had to look through a book, I went for the easy options, went through the websites, so for example I looked at question one and three and they both had two websites, so I thought those are the easy ones, because I don't go to the library for them, so I went there and went to the links. (P4Y2T2)

Like most students preparing for the examination, she initially used online information resources, such as Wikipedia, to help her understand the questions, locate background information and find definitions of terms. Her expertise manifested itself in an ability to save time and search tactically. Note that this is the same student who contacted the library to obtain help in accessing an online journal. Here she seeks to minimise as far as possible the time taken to find information, and expresses the preference for online material that we saw in all students. She exhibited sufficient independence in information seeking to use websites to access information quickly, which she perceived to be easier than undertaking research in the library.

Several students cited the importance of saving time and achieving search results quickly. P1 preferred Google because it was faster to search and meant she did not have to spend time travelling to or browsing in the library:

> So I was just thinking was it worth going there and looking for the books and then in fact they aren't that useful, I think the internet resources are more handy and at least faster, and I can do the search at home, even though it's not far to the library. (P1Y2T2)

She said that she had not got anything from the library "because it doesn't look like I need to". Her strategy was to look online for some information, to print it out and then read it and then look for more "just in case I'm in the wrong direction." This saved her time on reading unnecessary material.

Even when searching the internet, students wanted to find relevant material as fast as possible:

> I tried to search for the key words, at first I was just day dreaming, because when you look at something, you want to read something that is relevant and is useful for you to apply, but it was not very useful so I, I don't know, I'm so lucky on this one, I did it quite quickly. (P3Y2T2)

Students were now so focused on the demands of the task that they felt confident devising strategies to complete it in as little time as possible and with minimal effort. Several students felt confused by the demands of the course , and thus chose to limit the number of sources they used to avoid being presented with conflicting information. P6 presented the logic behind her decision not to undertake much independent searching for material. She believed the course handout provided more than enough information to equip her for the exam.

> We have books, online links and also notes, we have enough information to write a few hundred

> essays.[….] Yeah, it's better that we use the lecture notes, because it's more accurate, if we find information online, we aren't sure if it is correct or not, even when searching Google we find thousands of links, but we aren't experts, we cannot recognise what is accurate and correct. It's better to use the links that are provided and the notes. (P6Y2T2)

This demonstrates that the student now had enough knowledge to realise that her information skills were somewhat limited and she was aware of the differing quality of materials found on the internet. Yet she chooses to limit the range of sources she uses rather than finding new ones, as we saw in response to previous assignments.

Evaluation and confidence

The work for the cognitive science examination demonstrated an aspect of students' information behaviour which is especially well exemplified by the quotation above; that is: students' lack of confidence in their ability to process and evaluate the information that they had found. P6 insists that she is not an expert and so prefers to use her lecture notes, rather than using her existing skills to assess new material. The problem, it appears, is not so much one of being able to find material but that, once found, participants lacked confidence that they would be able to analyse and make use of it.

We can understand this in terms of an "information journey", described by Adams and Blandford (2005) as a process through which information seeking activities follow a cyclical pattern, from defining a need, initiating and performing a search for information, and then interpreting the information found relative to the current problem, and using the information, which in turn may initiate a search for further information. In the case of our participants, the stage of interpretation and evaluation was anticipated prior to searching, so that students might choose to redesign their query, or entirely reassess their information needs (such as the search for customised trainers above), rather than embark on the difficult task of interpreting what they had found. Under the stress of examination preparation students returned to old strategies of web searches and text books, so as not to have to interpret and work with too many, possibly contradictory, sources. For example P4 described her thought processes when preparing an answer:

> At the moment the question focus is on Xerox, so I went to the actual Xerox website, I don't really want to get anything from any other sources, just in case they say anything that contradicts what they [Xerox] say. (P4 Y2T2)

We had also seen this type of behaviour repeatedly in earlier interviews. For example, in the first year, one student (P13) was reluctant to use a course pack. He found it hard to find information he needed quickly because he found the pack too large and disorganised. He preferred web searching to the task of having to read, evaluate and compare

the information presented in a collection of different printed articles, with no obvious right answer. We found this kind of avoidance of interpretation in our participants during the whole study.

Although he also struggled to understand much of the Cognitive Science course, only P2 in our sample followed the kind of trajectory described by Adams and Blandford: his initial need was to find information to help him understand the course. He described using several sources of information in addition to the references provided on the seen exam paper. He was confident enough to progress from finding information to evaluating it, and using the appropriate sources to fulfil his information need, a task that the standard age students avoided. This also suggests that in this respect the standard age students in our study behaved more like school age students than mature information seekers. As Rowland's (2008) study shows, although numerous studies of young people's use of the internet have assumed that they are at ease finding and using information, they tend in fact to find difficulty in evaluating what they find, and need significant guidance to do so effectively.

It is therefore interesting to compare the strategies we witnessed with Kuhlthau's (2004) findings from a study of high school children. Kuhlthau observed that high uncertainty leads to conservative and sub-optimal strategies, and lack of both confidence and domain knowledge correlate with low commitment. The context of the examination was obviously one in which our participants were uncertain of the best strategies to use. When interviewed about their preparation for the examination, students repeatedly mentioned that they had a problem with understanding what a question required.

> Yeah, when I was trying to tackle this question I found the wording, it made me a bit unsure, yeah it says 'Critical assessment of research on sense making' and it says 'research underlying themes, directions taken and outcomes' and I thought it was a bit ambiguous and I thought ok, underlying themes could be anything, there are loads of themes in there, I didn't know how to pinpoint the answer to that. (P4Y2T2)

As we have seen, P4 was one of the students with more advanced search skills when she began the course. But faced with the unusual requirements of the seen examination, she did not exhibit similar confidence in framing search strategies. Her response to her lack of understanding was to avoid this question rather than looking for information to help her understand it.

It is notable therefore that, in the absence of the stronger framing typical of the High School context Kuhlthau observed, many students demonstrated little progress in either task or skill when preparing for the seen examination. Most students in our study were not experts, and the task was predicated upon the assumption of much higher levels

of both motivation and information skills than most standard age students possessed. Leckie (1996) argues that this is relatively common, since academics forget how complex their own skills are, and that students have yet to acquire such expertise.

The strategic satisficing stage is a fascinating one, in which we observed our sample gain significant expertise. However this skill was used in strategies that appear counter-productive from an information professional point of view. Participants in our study used knowledge about information sources to justify not using those sources they disliked. We also found a marked resistance in members of our sample to evaluating the information that they had found, comparing sources or broadening searches from the tightly defined keywords of assignment titles or examination questions. When faced with a difficult task requiring complex and varied information search, they used their knowledge to justify a limited strategy and worked out the minimum acceptable material needed to complete the work. Thus we cannot claim that our participants were acting like expert searchers, in the sense of any classic definition used in the literature. Rather, they had learnt to deploy their knowledge to achieve the tasks in the way that most suited their purposes. This behaviour can be seen as expertise in some sense, however unexpected.

Discussion

It is difficult to compare our results with those of earlier studies, because conceptions of what constitute a novice information seeker have inevitably changed in the last 25 years, even if the concept of expertise remains more stable. All students now have a greater exposure to online search facilities from an early age, and a greater amount of information is being searched and delivered electronically. It is now more difficult to define how long people have been searching online and they find it hard to remember how they learnt to do so. Thus, definitions like Harter's (1984) and Howard's (1982) which relied on attendance at specific courses or the number of searches performed over time, are no longer meaningful. It is also more difficult to decide what is meant by a single search. Our study has shown that a task may include several different search types across multiple sources, including subsidiary searching. We also found that participants' levels of expertise varied at the beginning of the study, and thus a simple novice to expert comparison was impossible to perform.

We have therefore presented our results as a holistic investigation of a set of activities related to different information tasks, since this complex and detailed process better reflects the way that expertise is acquired in information behaviour. Despite the students' preference for using the internet if possible, we found that experience in web searching is not synonymous with expertise in more general information behaviour. Many of the earlier studies discussed above appear to have made a tacit assumption that expertise was synonymous with experience, in other

words that a certain amount of practice in information work would inevitably lead to higher levels of skill. While this may indeed happen in certain cases, we believe that our results demonstrate that experience does not necessarily bring about expertise, especially if, as in this case, participants lack confidence in analysing and evaluating the utility of search results.

Our participants avoided the library, and used their expertise to develop strategies to find sufficient information for little effort. While they were well able to perform keyword searches, some of which were relatively complex, they proved unwilling to embark upon the second phase of the information journey and to interpret and use what they had found. When under stress, such as from the seen examination, where a strategy failed, or if they were unsure what to do, they tended to return to the pre-university habits of using a textbook or relying on recommended material, or to simply repeat an unsuccessful strategy using a different kind of information system.

Reliance on recommendation should not been seen as a novice information seeking strategy. As Whitmire (2002) shows, even relatively advanced student information seekers in their final year in college consider recommendation important. Barrett (2005) and Buchanan et al. (2005) have also shown that senior academic researchers in the humanities continue to rely on recommendations by colleagues as an important source of information. The difference between novice and expert in this respect is the role that such recommendations play (as being relied upon or being useful pointers). As Chu and Law (2007a) found, PhD students initially rely on material recommended by their supervisor, but do so less as they develop greater domain and information seeking expertise.

Task orientation

The extent to which students' information skills developed was directly related to the demands of the assignments set. As the sophistication of assignments increased, participants were forced to develop a richer repertoire of skills. This is not surprising, since academics teaching information management are aware of the need for students to become independent, expert information seekers. However, participants frequently prioritised the immediate acquisition of information over the development of their information-seeking techniques. Hence, improvement in information seeking skill was erratic. We found that the extent to which the behaviour of the students developed from that typically observed in teenagers and school aged students differed, but was still highly dependent on the information task. If they felt that the task required it, they were willing to try to use a wider range of information resources, despite a general dislike of books and library use. They also showed a willingness to think about the types of information they found and their relative usefulness and reliability This is the kind of behaviour rarely found in studies of younger children and teenagers. However, out participants retained the tendency found in such studies to

perform keyword searches, culled from coursework material or assignments titles, and not to alter or complicate their information seeking strategies when simple keyword searches proved inadequate.

Strategic satisficing

Perhaps the most interesting aspect of growing expertise in information behaviour was strategic satisficing. Most participants used their developing skill in a tactical fashion. For a given task, they estimated what the minimum literature requirements were, and chose specific goals that they could fulfil easily and quickly with their existing skills. Expertise was demonstrated, but typically through ingenuity in finding strategies that sustained existing skills. This was especially evident in the task that was designed to force them into genuinely independent information seeking: the seen examination. Rather than using the information seeking knowledge gained in lectures to use a few suggested initial references as the starting point for a thorough literature search, students used their information skills to spot the questions they considered to be the easiest to find material on, and which could be addressed by a conservative information strategy.

Some students had developed expertise to the point that they would try different types of searches, but often gave up if initial ideas did not work. This tended to coincide with the use of strategic satisficing, so that if they could satisfy a goal through less complicated searches, they would do so. It was evident that students' information skills would improve only if it was absolutely impossible for the student to find enough material through using familiar tactics. Active acquisition of new skills was seen very rarely in our participants, except in the case of P2, whose skills were already more advanced. This cautious mindset could be argued to represent a development in information seeking expertise, since the students have learnt methods for finding information which save as much time and effort as possible. Considered in these terms, strategic satisficing is a significant information skill, though one that limits future growth.

Strategic satisficing is not found in literature on the development of expertise in information seeking. This may be because the longitudinal studies that have been performed by Vakkari (2002) and Chu and Law (2007a, 2007b) have involved relatively expert graduate students, who were highly motivated and therefore made steady progress towards more complex searches. In addition Chu and Law's students were given help with search tasks if they were unable to perform a search themselves. It is therefore unsurprising that they will have made progress as a result. We chose not to direct our sample, but simply observed their choices in as naturalistic a fashion as possible. It is perhaps less easy to understand why Kuhlthau's sample of students did not seem to manifest this behaviour. It may be that high school students are more likely to listen to instructors, or that they respond more positively to the fact that their behaviour is

being observed (the "Hawthorne effect"). It may be that their work is more closely monitored, so that they make progress as a result of greater supervision. Cothey (2002) found that the undergraduates in her sample did not necessarily become more independent searchers; nor did they acquire a repertoire of trusted resources to which they returned repeatedly. Instead, they tended to become more passive, to browse, and to visit an eclectic range of websites. She hypothesises that this unexpected behaviour may be related to the undergraduate stage of development, but her large quantitative sampling techniques do not allow her to investigate motivation for this behaviour. One explanation for Cothey's results is that at least some of her sample students had learnt strategic satisficing.

In a previous paper (Buchanan et al., 2005), we reported indicative evidence that the evolution of search strategies was episodic, rather than continuous, and primarily triggered by overwhelming necessity. Our humanities academics in that study often reported their postgraduate training as a locus for their own growth. This data corresponds with the evidence of both Chu and Law and Vakkari, who saw changes when observing postgraduate information seekers. Our current study provides further evidence to support our earlier hypothesis.

Reflection on the learning theories of Kolb (1984), particularly his use of Lewin's (1951) field analysis technique, gives some further explanation. Kolb observes that learners will often resist acquiring new skills because rejecting existing skill causes negative emotions (confusion, anger, upset). Existing skill is guarded zealously and adapted repeatedly until it finally fails. This common reaction is clearly exhibited by our students as they resist development in their information seeking strategies. Expert searchers are therefore not only differentiated by their existing skills, but also potentially by their attitude to acquiring new ones.

Assumptions about levels of expertise

As we saw when considering the comments of the mature student in the sample, there is a mismatch between the experiences and expectations of different levels of information seeker. Experts misjudge the skill and resistance to change of novices. Academics expect students to behave in the way that an expert information seeker might: using available information as the basis for further searching, browsing and chaining, persisting until an acceptable result set has been achieved. However, only P2 of our sample behaved in this way. It is evident that the standard age students have not achieved the requisite level of information seeking expertise to undertake such an independent search.

Our study shows that less expert seekers are more likely to use what expertise they have to support the retention of familiar strategies and limit both the effort and scope of information seeking. The mismatch of expected and actual expertise in novices was also evident when too much information was delivered to students before they had acquired

the expertise to process it. For example, students initially found it difficult to use journal articles, as they lacked the background information to make the articles comprehensible: they lacked the scaffolding (Collins et al, 1989) necessary to assimilate and use the new information.

The challenge for the academics, who are information experts, is therefore to know at what time, and in what quantity and levels of complexity, it is appropriate to provide students with information, and at what stage they ought to be pushed to seek it for themselves. The same challenge will be found where developers of search engines wish to support the development of expertise through advice and guidance in the interface. In both cases, there is the additional complication of making the relevance of new techniques to the problem at hand clear. Without such a connection, adoption will be piecemeal and only by the keenest of users.

Limitations of the study

The main limitation of this study is that we were unable to follow the cohort of students into their final year. Thus, we do not know whether the experience of a dissertation or final year project might have provided the stimulus necessary for them to become independent information seekers, because of the range and depth of information necessary. However, much depends on the standard to which a student would like to complete a piece of work, and even such research projects might be completed using strategic satisficing and the minimum sources necessary. Judging by the experience of P2, it may be that it is only when students enter the workplace that the demands of their job force them to develop more complex information strategies and practice new methods of searching. To investigate such differences in search behaviour, members of our team have carried out a parallel study of search expertise in lawyers, where participants range from first year undergraduates to established professionals. Data from this is currently being analysed.

Conclusions

When compared to studies by Vakkari and Chu and Law, whose participants made progress towards full expertise, with ever more complex searches, better definition of terms, and a more varied repertoire of search strategies, our students' progress is arguably less impressive, but just as interesting, given what we have learnt about students' ability to satisfice and different stages in their information work.

Satisficing in information seeking has been described by others. For example, Choo (2007) studied information seeking and use in a corporate setting, and found that the organisation accepted a satisficing approach to information seeking; in other words, it was considered acceptable for staff to stop when they had found adequate information to

inform the current decision rather than seeking all the information that might be pertinent to that decision. Similarly, Zack (2004) reports on the activities of arts administrators in information seeking, focusing particularly on their approach of stopping when they have sufficient information for the task at hand. Prabha et al. (2007) develop an account of satisficing in information seeking based on role theory and rational choice theory. A common feature of all these studies is that they focus on the stopping criterion (when is enough enough?): although all recognise that people can feel overwhelmed by the sheer quantity of information available, none of them relates the satisficing behaviour to developing expertise. The study reported here has highlighted important additional facets of satisficing within the context of developing expertise: that, wherever possible, students select information sources and search strategies to lie within their 'comfort zone' in terms of both their understanding of the domain and their information seeking skills. They exhibit cognitive economy, not just in deciding when to stop searching, but also in what searches to conduct.

Information systems and digital libraries are no longer used only by highly expert searchers, but must be usable even by those with lower levels of information seeking expertise, and those less determined to finish a complex search. Compared to the self-selecting cohorts of postgraduate students and academics studied by others, our participants are more likely to be representative of the majority of information seekers, even though they are being educated in information management. Our findings about strategic satisficing are of significant value, as they show what a less expert searcher may do when overwhelmed by the complexity of a task or search, or when under pressure of time. Our students did not necessarily complete their information tasks but deployed considerable ingenuity in finding ways to avoid or limit complexity.

Further research is clearly needed into the phenomenon of strategic satisficing. Such research might employ a methodology similar to that of Whitmire (2002), and assess the epistemological ability of participants, to determine whether this has any bearing on the tendency of student participants to create easier paths through the information task. Strategic satisficing may prove to be related to a lack of motivation and a desire to spend time on tasks other than those directly related to information seeking, e.g. writing. All searching occurs in a context, and seeking itself is usually of lower priority than the driving context. The degree to which increasing expertise in a domain leads to increasing prioritisation of the information seeking task also requires examination.

The importance of our work, however, is in the finding that these progressing towards expertise do not necessarily do so in the ordered and positive fashion found by Vakkari and Chu and Law, whose participants were already at postgraduate level. Commitment to information seeking and information interpretation depends on the seeker's

motivation towards both the wider task and the seeking process itself. Development in information behaviour is also affected by a third factor: a dedication to acquiring and maturing new techniques. Our study suggests that many information seekers resist developing new skills and "satisfice" their searching efforts. New skills are only adopted if encountered when of immediate use, such as when a task requires it. This study suggests that academics and system designers should assume lesser motivation, but greater ingenuity, in students' information seeking than may currently be the case.

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